DEPARTMENT OF ECOLOGY

May 1, 2002

TO: Don Nichols, Water Quality Program - ERO
Ken Merrill, Water Quality Program - ERO

FROM: Bob Cusimano, Water Quality Studies Unit - EAP

THROUGH: Will Kendra, Watershed Ecology Section Manager - EAP
Karol Erickson, Water Quality Studies Unit Supervisor - EAP

SUBJECT: **RESPONSE TO REVIEW COMMENTS ON SPOKANE RIVER AND LONG LAKE TMDL DEVELOPMENT**

Ecology received review comments on the Spokane River and Long Lake TMDL study draft reports from representatives of the city of Spokane, Spokane County, Inland Empire Paper Company, and Liberty Lake Sewer and Water District. We found the comments to be very constructive and helpful in our development of the CEQUALW2 model. The following are our general and specific responses to comments presented in the cover letters and technical review attachments we received.

General Responses

1. *Model Review Opportunities*: We released the draft reports and draft calibration CEQUALW2 models for your review in response to the request of the stakeholders. The city of Spokane, in cooperation with the regional stakeholders, sent Ecology a letter dated October 1, 2001, signed by Dale Arnold, Director of Wastewater Management. The letter stated:

   > Can Ecology allow additional time before publishing 'even draft' numbers and water quality parameters developed from the model, during which time the dischargers can review and provide input into the model's input data and assumptions both fixed and variable? Can the dischargers obtain a draft final working model, evaluate output and comment before the final version is developed?

   We are continuing the model calibration process and the 1991 and 2000 calibrated models and associated reports will be finalized and posted on May 3, 2002. However, we are not planning to finalize the model calibration until October, followed by another review period, before preparing our draft technical report summarizing the model development and preliminary loading limits. This should provide sufficient time for the stakeholders to review and comment on the model. We are planning to publish a short technical memorandum summarizing the modeling results for some scenarios using the 2001 river flow and meteorological data (design year conditions) with the boundary loading conditions found in 2000. We will be doing this analysis to provide the dischargers and other interested groups or individuals with a preliminary loading assessment. This exercise is necessary because Ecology and the dischargers need to understand the estimated current impact on water quality and understand how the water quality criteria will be applied.

2. *Model Selection*: Ecology, in cooperation with the Corps of Engineers and Portland State University, collected both historical and new data to calibrate the CEQUALW2 model to 1991 and 2000 conditions. In selecting the 2-D dynamic CEQUALW2 model, Ecology recognized that the Spokane River and Long Lake system have specific physical features that require a more complex model than we have applied to other waterbodies to simulate water movement through the system. Specifically, the river has a number of dams with turbines and spillways that affect river flow and residence time. In addition, Long Lake has pronounced metalimnetic interflows and other hydrodynamic features that need to be considered when assessing water quality. However, the stakeholders should not confuse Ecology's selection of the model with model development in a research context.

   Ecology's goal is to develop a modeling tool that can be used to manage water quality in the Spokane River system. In the TMDL process, the model will help determine the wasteload (WLAs) and load allocations (LAs) necessary to restore and protect water quality. Achieving the assigned WLAs and LAs may require different levels of treatment to control the point sources or best management practices (BMPs) to control the nonpoint sources of pollution. Ecology is aware of the implications of additional treatment to the dischargers and is striving to create the best tool possible given time and resource constraints. While no numerical model can recreate perfectly the complex, time-varying interactions of every physical, chemical, and biological process, our goal is to have the CEQUALW2 model represent the primary and even some of the secondary processes that control dissolved oxygen. Although Ecology recognizes the need to apply good scientific principles, we also recognize that determining a level of treatment for a point source discharge or recommending BMPs in a watershed to mitigate nonpoint sources should not require an exhaustive scientific data collection and model parameterization process. Rather, the objective is to collect enough data to develop a scientifically based model application that is a **good approximation** of the system. We believe the Spokane CEQUALW2 model is being appropriately developed using the best available data. We also believe the model will be a good approximation of the major forcing processes and features of the system that affect water quality such as the hydrodynamics of Long Lake, pools associated with the dams, and pollutant loading. Finally, we believe the model will be an effective tool for recommending WLAs and LAs.

3. *Model Calibration*: The U.S. Environmental Protection Agency (EPA) has not provided specific guidance on model uncertainty analysis or guidance on what are the "acceptable" variances for determining when a water quality model is adequately "calibrated" to a specific variable so it can be used for establishing WLAs and LAs. The goal in the model calibration is to minimize the differences between model predictions and measured values and reproduce major physical and chemical processes (e.g., metalimnetic interflow in Long Lake, temperature stratification, and major variable concentrations). An important aspect of model calibration is to provide a model which does not have significant systematic model biases that could bias the evaluation of proposed management strategies. As part of the reporting documentation for the development of the CEQUALW2 model, we are providing commonly used error statistics and sensitivity analyses for the major variables and kinetics. Ecology is also planning to ask EPA to

provide a technical review and assessment of the model as an appropriate tool for establishing WLAs and LAs.

Even though we will attempt to evaluate model sensitivity, due to resource and time limitations we will not provide an exhaustive assessment of each model variable or parameter uncertainty or sensitivity. However, all interested parties will be provided the study reports and models and can conduct their own analysis of model uncertainty or sensitivity for variables or parameters of specific interest. The results of any analysis can be submitted to Ecology for consideration during the public review process scheduled to occur during the summer of 2003.

4. *Model Uncertainty*: Ecology recognizes that there will be data and model uncertainty associated with recommending WLAs and LAs to meet any TMDL. The Clean Water Act requires that any lack of knowledge about the system must be accounted for by establishing a margin of safety (MOS) in developing a TMDL. The implicit (conservative assumptions) or explicit (reserving a portion of the loading capacity) MOS must be identified as part of the TMDL as it undergoes public review. Ecology believes that current water quality regulations require that pollutant loading sources bear the burden of that uncertainty and not the environment. In support of this position, we cite the following documents:

> Clean Water Act Section 303(d) (1) (C)
>
> (C) Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.
>
> Code of Federal Regulations Section 40 130.7(c) (1)
>
> (1) Each State shall establish TMDLs for the water quality limited segments identified in paragraph (b) (1) of this section, and in accordance with the priority ranking. For pollutants other than heat, TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical WQS with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. Determinations of TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters.

The following responses and comments (normal text) to the review comments (*italic text*) are arranged by each letter or memorandum we received.

Response to Comments from Gerry Shrope, Consoer Townsend Envirodyne Engineers (CTE), Inc. to Tom Arnold (March 29, 2002 Memorandum)

We did not receive an electronic version of the CTE comments and did not include the specific comments with our responses. Please reference the CTE memorandum for each of the categories of comments listed below.

Uncalibrated Input

Chlorophyll-a

The final report and model scheduled to be posted on May 1, 2002, will provide a comparison of chlorophyll *a*.

Epiphyton

There are essentially no epiphyton data to compare with for the calibration years, but the numbers from the model are consistent with the historical measurements and the 2001 data. However, diurnal changes in dissolved oxygen and pH are good surrogates for epiphyton productivity, and the model is matching these well. (There is a significant amount of variability in the historical field measurements of epiphyton in the river, such that epiphyton expressed as chlorophyll *a* have ranged between 3-34 mg chl a/m^2 upstream of Barker Road and 61-600 mg chl a/m^2 in the downstream reaches of the river. Currently the model is predicting values within this range.)

BOD

We are using direct measuremts of organic carbon and nitrogen together with other measured constituents to partition oxygen demands into their various components. We will compare the model results to the total organic carbon, total nitrogen, and ammonia measurements to verify that the model is appropriately simulating the oxygen demands in the water column. In addition, we will compare the model results to a few ultimate CBOD measurements that we collected.

Bacteria

It is unclear what the reviewers mean by "uncalibrated bacteria." The model is not currently being calibrated to simulated fecal coliform or other bacterial pollution because it is not an objective of this study, but the model can be used to simulate bacteria pollution if calibration data are collected. If the comment is in reference to nitrifying bacteria processes, we are not simulating nitrifying bacteria and are not aware of any other routinely used water quality model that includes nitrifying bacterial dynamics.

Organic Fractions of Nitrogen and Phosphorus

No direct measurements of organic nitrogen and phosphorus (there are no direct analytical methods for organic phosphorus) were collected, and any comparison with back calculated values from other measurements would be highly suspect and not worth pursuing. In the May 1, 2002, release of the model and associated calibration report, we will include comparisons between model predictions and ambient data for total nitrogen and total organic carbon. These comparisons together with comparisons for oxygen, pH, alkalinity, chlorophyll *a*, ammonia nitrogen, nitrate-nitrite nitrogen, and soluble reactive phosphorus should provide a good assessment of the models ability to represent the major water quality constituents of concern.

Impact of Uncalibrated Inputs on Efficacy of the DO TMDL Model

As noted in the general comments and in the specific responses above, we are continuing the 1991 and 2000 calibration and additional results will be posted on May 1, 2002.

Model Coefficients

The algal settling rate has been set back to the default value of 0.1 m/day.

Algal stoichiometry is set at default values and will be evaluated against algal productivity data.

The burial rate is not 40 m/day for epiphyton. This is the half-saturation value for algal biomass limitation, which is a function of self-shading, nutrient diffusion limitation, and shearing of epiphyton, and is in the units of 40 g/m^2. Model epiphyton productivity is currently within historical and current measured ranges.

The nitrification rate will be adjusted to more reasonable values for Long Lake.

There is no source for SOD values – these were true calibration values necessary to reproduce observed DO. They will be modified based on final calibration. However, we believe the values are very reasonable.

During the growing season (June through October) inorganic suspended solids are an inconsequential player for light extinction in Long Lake. The value for organic suspended solids will be reset to 0.2. Again, however, model results for Long Lake are insensitive to the value specified. Values will be compared to secchi disk and field measurements or estimates of light extinction.

Summary

As noted in the general comments section, we distributed the model for review in order to provide the stakeholders with an opportunity to begin to review the modeling work. We will have the final working calibrated model and documentation available by May 3, 2002.

Response to Comments from David W. Dilks, Limno-Tech, Inc. (March 29, 2002, Letter Addressed to Ken Merrill, Ecology)

Three summary conclusions can be drawn from this review:

1. *Neither the modeling analysis nor the documentation have been completed to the point where a final review can be conducted at this time. Ecology openly recognizes that the work is incomplete and ongoing.*

   1991 and 2000 model calibration will be completed by May 1, 2002. The model will also be calibrated to 2001 data collected by the stakeholders and Ecology, which may require some modifications to the 1991 and 2000 calibration results. The final calibrated models are scheduled to be completed by October 1, 2002.

2. *The modeling analysis includes calibration (ongoing) to two separate years, 1991 and 2000. However, Ecology does not plan to actually verify or validate the model.*

   The following response is from Tom Cole, U.S. Corps of Engineers:

   The fact that we call 1991 and 2000 both calibration years is a question of semantics and has nothing to do with science or whether or not one does or does not have confidence that the model is accurately reproducing prototype behavior for the "right" reasons. For example, consider the following table in which sufficient observed data are available for model calibration.

Year	Flow	Stratification	Fall algal bloom	Minimum DO at dam
1989	high	weak	yes	0 ppm
1990	low	strong	no	3 ppm
1991	average	medium	yes	1 ppm
1992	average	medium	yes	3 ppm
1993	low	strong	yes	1 ppm
1994	high	weak	no	3 ppm

Which of the years should be used as the "calibration year" and which of the years should be used as the "verification" year? One could argue a whole host of different combinations such as 1989 and 1994 because similar flow years resulted in different responses of fall algal blooms. Other years could be chosen based on DO criterion. The "correct" answer is to model all the years if there is sufficient time and money and not separate them out into a "calibration" year and a "verification" year but rather model them all continuously. Reproducing all the variations in algal response and DO over the five year period will result in a great deal more confidence in the model's ability to accurately portray different scenarios even though there would be no separate "calibration" and "verification" data sets.

Taking this one step further in which in one data set it is acceptable to change model coefficients to match data and it is unacceptable to change coefficients for another data set, here is another example of the ineptness of the concept of calibration/verification as is currently accepted in modeling circles.

Year	Dominant algae	Flow	Minimum DO at dam
1979	diatoms	average	5 ppm
1986	greens	average	3 ppm
1994	bluegreens	average	0 ppm

Regardless of which years are chosen for the calibration/verification years, clearly the coefficients related to algal kinetics should not be the same for all the data sets as the algal community has changed over time due to eutrophication. The ideal solution would be to model the entire time period from 1979 to 1994 and see if the model was capable of simulating the eutrophication that has taken place, but it is highly unlikely that sufficient data would be available to do this. Subsequently, algal kinetic coefficients such as settling velocities, nutrient half-saturation values, growth rates, etc. should be different for the simulated years, which is not in keeping with the concept of calibration/verification.

Because of the aforementioned problems with the calibration/verification concept along with numerous others, we call the entire process calibration in which the goal is to reproduce as wide a range of conditions in the prototype as is possible given time and monetary constraints. Validation of the model is based on comparisons to numerous analytical solutions and on over 100 previous applications in which the model has reproduced a very wide range of complicated prototype behavior using essentially default values for the hydrodynamic and kinetic coefficients.

3. *No fatal flaws in the modeling have been identified in the documentation provided to date.*

   No response needed.

Draft Spokane River and Long Lake Total Maximum Daily Load Study Data Summary Report

4. *The Data Quality Results section lists several data quality problems where sample results had to be qualified due to quality control problems as "the associated numerical result is an estimate." The report lists which samples needed to be qualified and the reason for doing so, but it does not describe how these qualified data were used (if at all) in the subsequent analyses. This description is required.*

   The data were used as reported by the laboratory. "J"-qualified data mean that the analyte was positively identified and a value reported, but the lab considers the associated numerical result an estimate. We listed the reasons for the qualifier and our general assessment of the data. A "J"-qualifier does not mean that the data are incorrect, but the lab noted potential problems with the result.

5. *When discussing quality control of the effluent CBODU data (page 22), the report states: "CBODU mean values reported by Pelletier (1994, 1997) were used for modeling the Inland Empire Paper Company's (IEPC) effluent characteristics for this study (i.e. not the 1999 and 2000 mean values)." Justification for discarding recent data for historical values needs to be provided.*

   We did not discard the data we collected in 1999 or 2000 but compared them to the CBODU data collected in 1995 as part of a study by IEPC together with Washington State University (WSU) Environmental Engineering Labs to determine the BOD characteristics of their specific paper processing effluent. In a meeting with some of the dischargers during the fall of 1999, representatives of IEPC expressed concern that considerable effort was undertaken to establish their effluent specific CBODU characteristics. We agreed and decided to use their data for establishing IEPC's CBODU/BOD5 ratio and decay rate. However, we will reevaluate the ratios and decay rates with the additional data collected in 2001 and, if necessary, make changes to the values used for 2000 (the values used for 1991 will stay the same).

6. *Page 26 states that "diurnal changes in dissolved oxygen concentrations (and pH) are likely due to organic substance decay and photosynthesis and respiration of floating and attached algae." Justification for including organic substance decay needs to be provided to describe how it has any bearing on diurnal changes.*

   We agree that the words "organic substance decay" should be removed from this statement.

7. *Water quality goals for Long Lake need to be clarified, as the report implies that they will be changed from existing levels. The report (page 32) states that:*

   > *The Long Lake total phosphorus TMDL was based on meeting an "average" euphotic zone chlorophyll a concentration during the summer/fall growing season for the whole lake. However, the lake is long and narrow and the major tributary phosphorus loading travels through the shallow, narrow upper portion of the lake that is susceptible to eutrophication. The recommended current TMDL allocation will not protect the water quality of the upper part of the lake…*
   >
   > *If the chlorophyll a target for the lake is going to be changed, the new target should be made public as soon as possible for public review such that its adoption does not further delay the TMDL process.*

   The adequacy of the existing phosphorus TMDL will need to be addressed as part of the final report for this project and be presented as part of the public process. The complete text in the cited draft report discusses our concerns. Please note that chlorophyll data and observations of algal blooms suggest that the upper part of the lake will likely regularly exceed the average and more importantly the peak chlorophyll concentrations that were predicted to occur at the phosphorus TMDL concentration value during the June through October period.

   Long Lake's morphology and hydrodynamics are such that an average condition is not representative of the upper lake. The upper nine to ten miles of the lake (where most of the residential areas are located and aesthetic values and other beneficial uses of the lake are very important) is riverine, such that the phosphorus concentrations are about equal to the concentrations in the river. The lower or downstream portion of the lake is deeper and strongly stratifies during the summer such that the phosphorus concentrations in the euphotic zone represent mixing of water with different residence time and concentrations (i.e., phosphorus concentrations are lower than those in the upper part of the lake). Therefore, the response of the riverine portion of the lake to nutrient loading and river flow is very different than the rest of the lake (especially during the late summer and early fall) and should be considered in setting criteria to protect this area of the lake. The lake response and loading assessment analysis for establishing the current total phosphorus criteria treated the euphotic zone as homongenous. Consequently, the "allowable" phosphorus loading was biased high relative to the riverine portion of the lake.

Upper Spokane River Model: Boundary Conditions and Model Setup

8. *The introduction (page 7) states that the goals of the modeling are to accurately simulate the water quality constituents of temperature, dissolved oxygen, and nutrients. Algae, a critical*

component of the Long Lake nutrient balance, are not mentioned among the constituents of interest. It is not clear whether this is an oversight or a conscious omission. Algae (or phytoplankton) must be considered to be one of the primary water quality constituents of concern.

This information will be provided in the final report.

9. *Two alternate approaches for simulating organic matter, termed Method 1 and Method 2, were described starting on page 40 (and repeated elsewhere). The reports need to make clear which of these methods are being used during the subsequent simulations.*

   Method 1 was used in the initial model analyses for all the tributary and point sources. The current calibration model uses only Method 2 for the dischargers. It may be clearer to delete this section on Method 1 from the report. All point source discharges are modeled as a separate CBOD group that includes its effect on dissolved oxygen and nutrient recycling. Authochthonous production of organic matter is still however modeled as labile/refractory dissolved and particulate organic matter.

10. *Several assumptions are provided on pages 40 and 41 regarding the chlorophyll a content of algae, the carbon content of organic matter, and the fractions of particulate and dissolved matter that were in labile form. The basis of these assumptions, included whatever data they were based upon, needs to be provided.*

    This information will be provided in the final report.

11. *The statement on page 78 that "The decay rate for the CBOD was obtained from the Washington Department of Ecology" needs to be explained in more detail.*

    The individual CBODU calculations and summaries are provided in the files referenced and associated with the final data summary report. We will provide a more detailed description of how the CBODU values were calculated in the final data summary report.

12. *The chlorophyll a data graphed on Page 160 appear to be incorrectly labeled, as the information makes no sense as presented.*

    The graph will be corrected in the final report.

Upper Spokane River Model: Model Calibration

13. *Similar to the Boundary Conditions report, the introduction (page 1) states that the goals of the modeling are to accurately simulate the water quality constituents of temperature, dissolved oxygen, and nutrients. Algae, a critical component of the Long Lake nutrient balance, are not mentioned among the constituents of interest. It is not clear whether this is an oversight, or a conscious omission. Algae (or phytoplankton) must be considered one of the primary water quality constituents of concern.*

    This information will be provided in the final model calibration report.

14. *As noted in the revision list, the tables of error statistics for all constituents are largely blank and need to be completed.*

    This information will be provided in the final model calibration report.

15. *Predicted temperature profiles for the Spokane River upstream of Upriver Dam show a consistent over-prediction of observed temperature (Figures 23-26, pages 22-24). This discrepancy should be evaluated to ensure that no systematic bias exists.*

    We will re-examine the temperature predictions upstream of Upriver Dam.

16. *As noted in the revision list, the table of model calibration parameters (Table 17, pages 39-41) is blank and needs to be completed.*

    This information will be provided in the final model calibration report.

17. *The basis for selecting the sediment oxygen demand rates (e.g. observed data, model calibration, literature values) specified on page 56 needs to explained.*

    Again, SOD values are pure calibration values determined by matching observed dissolved oxygen.

18. *The process of entrainment of excess dissolved oxygen in turbulent sections of the river, theorized on page 63, needs to be justified. Photosynthetic oxygen production should be considered as a cause for the supersaturation.*

    We agree that photosynthetic oxygen production is most likely the cause of DO super saturation in late winter. This will be corrected, but the fact that the model does not match the super saturation has no impact on the usefulness of the model to address spring, summer, and fall DO, which are the primary times of concern.

19. *Detailed review of the draft water quality calibration cannot be conducted at this time, because no comparison of predicted to observed phytoplankton data are provided. Proper simulation of algal dynamics will be required to simulate most of the other water quality constituents (i.e. dissolved oxygen, nutrients, pH) of concern. It is apparent from some of the pH comparisons for Long Lake that algal production may not currently be properly simulated.*

    This information will be provided in the final calibration reports.

20. *The basis for selecting the ammonia preference factors (e.g. observed data, model calibration, literature values) specified on page 113 needs to explained.*

    This information will be provided in the final calibration reports.

21. *The basis for selecting the phosphorus half-saturation coefficients and stoichiometric equivalents (e.g. observed data, model calibration, literature values) specified on page 127 needs to explained.*

    This information will be provided in the final calibration reports.

22. *As noted in the revision list, the sections on Model Sensitivity Analysis and Model Kinetic Coefficient Analysis are completely blank. These sections are essential to conducting a review of the credibility of the modeling work.*

    This information will be provided in the final calibration reports.

23. *As noted in the revision list, Appendix 1 (Control File listing) is blank. This section is needed to make clear exactly what models were run to produce the calibration plots.*

    This information will be provided in the final calibration reports.

Responses to Comments from Esvelt Environmental Engineering (Letter to Inland Empire Paper Co. March 27, 2002)

Spokane River and Long Lake Total Maximum Daily Load Study Data Summary Report

1. *This Draft Report contains a description of the Spokane River, including Long Lake, and data used for development of the Model. It appears that it should be expanded to incorporate 2001 sampling results and description of the Idaho portion of the river.*

   We will incorporate the referenced work into the document before it is finalized. This will require that the stakeholders provide us with appropriate documentation on data collection and quality control and quality assurance procedures for data collection and analysis.

2. *It states on page 22 that CBODU mean values reported by Pelletier (1994, 1997) were used for modeling Inland Empire Paper Co (IEP) effluent characteristics for this study, and not the actual values collected for 1999 and 2000, even though the 1999 and 2000 concentrations measured by Ecology fell within the range of values reported in Pelletier (1997). A more complete description of the reason for this should be included.*

   See response to Limno Tech, Inc. comment # 5.

3. *Other data is listed as qualified. During model statistical and sensitivity evaluation it should be determined if these qualified data could cause model instability or add to errors.*

   See response to Limno Tech, Inc. comment # 4. There is not any specific variability associated with the qualified data that is “different” than the rest of the data collected, i.e., the data cannot be assessed as “different” than the other data collected for the project.

4. *Groundwater quality data used for model calibration appear to be from a single data set collected in 1999 for a limited area along the river. Additional data may now be available from a greater diversity of locations and time, which should be used for calibration (Contact Stan Miller, Spokane County).*

   We used the groundwater data collected in 1999 from near Sullivan Road because, after reviewing historical groundwater data, the Sullivan Road data appear to best represent water that we know is actually entering the river. The 2000 data suggest that groundwater in the lower part of the river and upper part of the lake has higher conductivity than the water entering in the upper part of the river. We are currently reviewing other groundwater data to determine if it may be more representative of the groundwater in this area. We did review the 1998-99 well data provided by the county; however, except for nitrate-N, the data collected by the county do not include variables of interest for our study.

5. *Discussion of water quality, and the Conclusions for this report imply that it may be the opinion of Ecology that the criteria for Long Lake, based on season-long average chlorophyll a concentration, may not be appropriate. Although no alternative standard is presented, the discussion implies that the chlorophyll a seasonal average criteria should be applied at all times at all locations. If this modification in water quality policy is proposed, it should be submitted to public scrutiny and review prior to such proposal being considered for adoption.*

   See response to Limno Tech, Inc. comment # 7.

Upper Spokane River Model: Boundary Conditions and Model Setup

6. *Model selection is discussed. It appears that the CE-QUAL-W2 model selected is a highly sophisticated and potentially accurate model, based on review of the model at the workshop and these reports. Whether it is a usable model may not yet be well verified, from the standpoint of ease of use, ability to use for multiple alternative variations in loadings, and ease of adaptation to alternative scenarios.*

   As noted previously, we selected the CEQUALW2 model to more accurately simulate aspects of the Spokane River system that other, simpler hydraulic and water quality models cannot represent. In addition, the model was selected in order to predict water quality changes under more realistic “dynamic” conditions such that the water quality evaluation and associated loading limits using the model will be more closely related to actual conditions in the river system. In order to gain this level of sophistication, the structure and function of the CEQUALW2 model has to be more complicated than other models that may be easier to use but do not provide as accurate representation of the system. However, we believe the model is not as difficult to use as the reviewer implies. We have run the model and made changes to needed input files to do alternative scenarios and found that it does not require an excessive amount of work.

   The current model’s run-time is of particular concern for calibration but should not prove to be a liability when using the model as a management tool. A year simulation currently takes about 36 hours of CPU time or two days wall clock time. The time necessary to plot, analyze, and understand the model output is approximately the same, so the time needed to run the model is about equal to the time needed to analyze model results. Currently, we do not see runtimes as a liability for using the model as a management tool.

7. *The use of labile and refractory organics in dissolved and particulate form, vs the use of CBODU as parameters for carbonaceous oxygen consumption in the modeling is presented. Either or both may be used in the model. It should be explained which approach is used (Method 1 or Method 2), and when and where, if applicable, in the model.*

   See response to Limno-Tech, Inc. comment # 9.

8. *It appears that division of the TOC into the organics categories is based on assumed factors. The assumptions for attributing TOC and algae into the categories should be explained more fully, and the effect on accuracy and error statistics of the assumptions should be analyzed and presented.*

   With respect to the application of the organic matter partitioning method, see response to Limno-Tech, Inc. comment #9. The impact of organic matter from the dischargers on dissolved oxygen and nutrients was modeled using effluent CBODU and BOD5 data which did not require partitioning of TOC into other organic matter compartments. The effects of the partitioning at the upstream boundary and tributaries can be evaluated through sensitivity analyses. However, small changes in the partitioning in these should only have a very small effect on the overall carbon balance in the system. As noted previously, the model is available to you and others to conduct sensitivity analyses to answer your specific questions.

9. *Concentrations for many constituents appear to be constant throughout the year 1991 in the river at State Line, Hangman Creek, Little Spokane River. It should be explained how this affects model calibration.*

   Ideally, we would have a time series of data collected for all variables. However, in most water quality modeling projects, some variables have to be estimated. We used the 1991 data set because it was a very comprehensive assessment of Long Lake and included data for the lower part of the river system including Hangman Creek and the Little Spokane River. We will report on the significance of the major water quality variables through sensitivity analyses.

10. *Flow through the turbines at Upriver Dam appears to be a stepped function (Figure 53). This is unlikely to be the case. Is this based on a rated flow and number of turbines in operation? Patmont estimated turbine flow from power production and differential head, which should possibly be considered. Flat line step function flows through the turbines at Upriver Dam would skew the flow balance for both upstream and downstream reaches from this location.*

    It is highly unlikely that using a step function as opposed to linearly interpolating the flow through the turbines will have any impact on water quality. Regardless, we feel that this should not be changed, as there is not a "more accurate" way to represent the turbine flow.

11. *Groundwater inflow to the river and outflow from the river by reach is estimated using previous data and gage readings. The data accumulated is not included in the report. It should be made available for review of those involved in Spokane Aquifer studies. They may have insight into the accuracy and reliability of the estimates.*

The data used to develop regression and constant estimates for 1991 and 2000 inflows and outflows was provided to the stakeholders. However, we will provide better documentation in the final *Boundary Conditions and Model Setup* report as to how each of the designated water body flows where established.

12 For many river reaches groundwater estimates are presented:

- *Rating curve accuracy for the reaches from Post Falls to Harvard Road and from Harvard Road to Barker Road. Reason for questioning gage readings should be presented.*
- *Discussion of Barker Road to Sullivan Road reach is confusing. It is unclear if the relationship discussed refers to high river or high aquifer flows.*
- *Regressions, where used, should be presented.*
- *Use of flow estimates from AVISTA may be suitable, but method of estimation should be presented.*

We will provide a better description of how river flows, including how inflows and outflows were established. Stan Miller, Spokane County provided information on gage readings at Harvard Road and Barker Road. In an April 15, 2002, memo to Ecology, Stan Miller noted that rating curves were re-evaluated February 2002. It is our understanding that USGS and Stan Miller suspected errors in the lowest flow readings. AVISTA provided turbine and spillway flow estimates (and pool elevation data) for their dams. Just as with any other professional group (e.g., USGS) we are relying on their expertise in establishing flows for their facilities. If the reviewers want to evaluate the estimation or measurement methods used by AVISTA, they can contact them and conduct their own evaluation.

13 Overall the flow balance is highly critical to the accuracy of the model, according to Tom Cole and Scott Wells in their presentations at the Portland workshop. The river/aquifer exchange through the Spokane Valley, needs to be described in further detail to allow comment. Estimated groundwater exchange in some branches was developed from regressions between monitoring stations. The regressions are not presented. On other branches, there are references to information sources in the descriptions of derived groundwater exchange, but there are several available information sources which are not cited. For example, Patmont, et al. (1985) mean estimates for inflows was used. In 1987, Patmont presented additional data, including information about river/aquifer exchange for lower flow rates, which varied significantly from the means. A discussion of how the groundwater estimates, and their errors (standard deviations presented) affect model calibration and error statistics should be presented.

See response to comment 12 above. Please note that the referenced Patmont documents and data used to establish relationships presented in the documents were evaluated as part of our review and we will provide a discussion in our final report on how these data were used.

14. *In run-of-river reservoir branches, it appears that inflow/outflow is distributed among branch segments according to surface area of the segment. This would not reflect actual conditions, where the difference between river water surface level and groundwater level (the driving force) changes along the length of the reservoir. This factor may not be particularly significant in predicting conditions in Long Lake, but in some upper river areas where the modeled dissolved oxygen concentration is very close to the water quality standard, it could have a significant effect. A related issue is the water quality parameters for the exchanged flows – temperature, for example, of water flowing out to the aquifer could be different at different points of the reservoir. It is not absolutely clear in the available documentation that the surface layer parameters aren't being applied to all inflows/outflows. These issues are also valid for branches of the river where spillway or powerhouse discharge information is used to adjust distributed tributary flows to balance the reservoir water budgets. Note that the "transition zones", where groundwater exchange changes from inflow to outflow (or outflow to inflow) will migrate upstream and downstream depending on river and groundwater levels. Consideration of the affect of these issues on the model and the error statistics should be included and discussed.*

    Although we agree with the general approach that water surface level and groundwater level differences will change along the length of the reservoirs (and river) and possibly affect the exchange of water differently, it is unclear what the actual changes would be because there is not sufficient well or flow data along the run-of-the-river reservoirs to show those changes. For example, your company prepared an engineering report for Inland Empire Paper Company dated June 30, 1999, that proposed changes to outflow estimates from the Upriver Dam pool based an assumed head difference between the water level in the pool and groundwater. In reviewing well water surface elevation data for a well located just upstream of the dam at Felts Field, the difference in well elevation and pool elevation appear to be less than assumed in the engineering report (and changes about 10-15 feet during the year). We believe modeling the river inflows and outflows as branch specific in the model (i.e., not segment specific) is a reasonable approach and provides good resolution with respect to river inflows and outflows.

    It should be noted that we are "balancing" the river flows with data or flow relationships from the following control points in the modeled system: the USGS gauge near Harvard Road (data and relationship with the USGS gauge at Post Falls), USGS gauge near Barker Road (data and relationship with the USGS gauge at Post Falls), Upriver Dam turbine/spillway, Green Street (flow relationship with USGS gauge at Spokane), Upper Falls Dam turbine/spillway, USGS Gauge at Spokane, Nine Mile Dam turbine/spillway at Seven Mile Bridge (flow relationship with USGS gauge plus Hangman Creek flow), and Long Lake Dam turbine/spillway. Although some unknown flow variability probably exist within each branch (e.g., Upriver Dam pool is represented as one of the 12 branches that make up six waterbodies in the model), we believe that the overall river flows are well represented in the model.

15. *Ground water quality for modeling is based on samples from one location only. It was shown during Spokane Aquifer '208' studies that aquifer water quality degrades as it progresses through the Spokane Valley due to the influence of on-site sewage disposal discharges, storm water injection wells (dry wells), and other influences. In addition ground water in the downstream area has other influences. The input of groundwater quality should reflect available data from the vicinity of the inflow to the river to the extent possible.*

See response to comment # 4. Sullivan Road data for nitrogen and phosphorus (major groundwater variables of concern for the Spokane TMDL study) are within the range of values reported for more downstream wells by Patmont (1985).   However, if you know of other data for wells near the river (and along the length of the river) please provide a specific reference.

16. *For point discharges the subject of organic matter vs CBODU use in the model is again presented. The assignment of TOC values toward OM estimates is a fixed factor. Since few of the reviewers are familiar with this approach, it would be beneficial to explain fully the origin of the estimating factors. It is not clear which method (Method 1 using organic matter, vs Method 2 using CBODU) is used during the modeling and calibration. Error statistics should be used to compare the two methods. For model use, the dischargers will be more familiar with potential changes in their CBODU (probably estimated as a function of* BOD_5*) from projections of future growth and treatment plant and operation improvements.*

    See response to Limno-Tech, Inc. comment # 9.

17. *For the discharger water quality (Figures for each discharger), it appears that average data is used as a constant value throughout the year in the model calibration.   The affect of this on the model calibration and output should be explained.*

    For some variables, average or estimated values were used.   We will include a sensitivity analysis for the major variables of concern.

18. *CBODU is not shown for the discharges. Explain if "Method 2" model calibration was done.*

    See response to Limno-Tech, Inc. comment # 9 and # 11. The input files for each discharge includes the CBODU estimates based on reported BOD_5 data.

19. *Organic Matter (Labile and Refractory DOM and POM) are shown as constant values throughout the year. The effect on the model should be explained.*

    We will include sensitivity analyses results as part of the final calibration report.

20. *Data used to derive the organic matter estimates (TOC, COD) should be presented.*

    TOC data were provided as part of the Data Summary Report (attachment). There were no COD data used.

21. *TDS is shown as 0 mg/l for most dischargers. This could be estimated from Conductivity (TDS, mg/l » 0.6 x Conductivity, mmho/cm).*

    We do not view TDS in the effluents as significant for modeling the far field effects of the point sources because vertical mixing is accomplished quickly in the river model.

22. *Phosphorus in Spokane Wastewater Treatment Plant (SAWTP) effluent is shown as constant throughout year 2000. It varied seasonally similar to 1991 (and 2001).*

    All of the phosphorus data reported for the SAWTP was included in the input file, i.e., it was not treated as a constant.

23. *Meteorological data was derived from the weather station at Spokane International Airport and applied for the entire river. This may be inappropriate, given the notable differences in short and long-term averages between the weather data at the Spokane weather station and the weather data for Coeur d'Alene. This includes temperature, precipitation, cloud cover, wind, etc. At least limited meteorological data should be available from Felts Field, Coeur d'Alene, and perhaps other locations. This issue takes on an even more critical nature when the model is extended into Idaho. An explanation of the affect on the model of using the Spokane data, if variations occur should be included.*

    Figure 1 shows a map of the Spokane River area and the location of several sites with meteorological data (plus symbols with circles). Coeur D'Alene is approximately 12 miles from the state line so it was considered too far away from modeling the upper section of the Spokane River in Washington. We also do not have data for this site. With the upcoming extension of the river model upstream to Coeur D'Alene, the river section in Idaho would probably use the meteorological data from the Coeur D'Alene airport.

    The Odessa site was the only site in the area that collected solar radiation data. We were interested in these data to compare with theoretical solar radiation for this latitude and to assess the cloud cover for the model. Cloud cover data are collected at the Spokane International Airport and Spokane Felt Field but at very poor resolution. We initially determined that using the solar radiation at Odessa would be appropriate. We will, however, complete an analysis of cloud cover as computed from Odessa radiation and measured coarse cloud cover at Spokane International Airport.

    The Felts Field data were not used because only data for 2000 were available at the time. It may be possible to get the data from 1991 but methods for acquiring it were exhausted in order to move ahead with the modeling study. Whether data from the two sites are similar has not yet been verified. An analysis will be conducted to compare the data at the Spokane International Airport and Felts Field and these results will be included in the data report. Additional model simulations will be conducted including the meteorological data from Felts Field in 2000 for the upriver section of the model to determine how sensitive the results are to this forcing.

    If anyone involved in the review process has access to the meteorological data at Felts Field from 1991 up to and including 1999, we would greatly appreciate the data. We would also be interested in the meteorological data at Coeur D'Alene for 1991 to 2002. We have done some GIS mapping showing meteorological sites in this area of Idaho and Washington and we believe we have found the sites with available data for the modeling time periods. If anyone knows of any additional data at other sites in the area, please let us know and it will be incorporated into the analysis and modeling work.

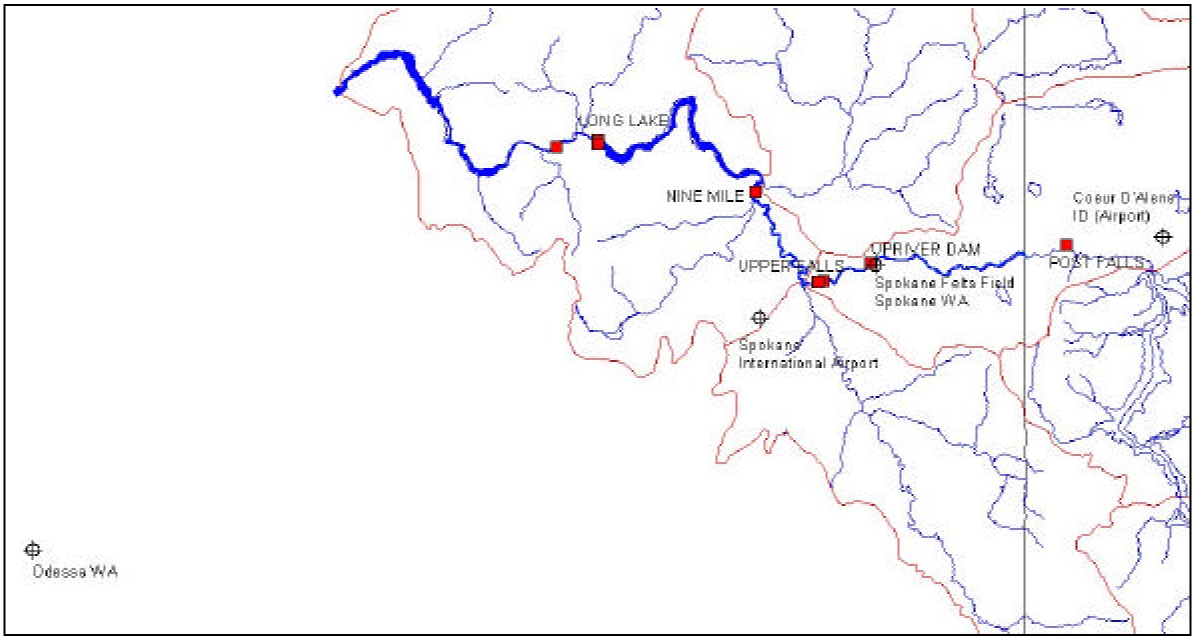

Figure 1. Meteorological Sites in Spokane River Area

24. *Wind sheltering of various river reaches was discussed at the Portland workshop, and it appears that model adjustments will be made to allow sheltering to be specific by river reach.*

    Yes, the model has been modified to allow the wind sheltering coefficient to be adjusted as a function of segment number.

25. *Periphyton data collected in 2001 was included in the report. This data, correlated to water quality and hydrological conditions in 2001 will hopefully be used in model calibration, which will allow assessment of the effect of this variable in the model.*

    We will use the periphyton data for the 2001 model calibration.

Upper Spokane River Model: Model Calibration

26. *Model calibration was performed for the two years, 1991 and 2000. Determination of model parameters that will allow the model to have minimum errors for these two years is the apparent goal. It is not clear how near finished this task is currently. The model for the two years was run and data graphically presented to show model fit to actual data. Overall the fits seem reasonable, but statistical evaluation of the comparative model and data is not complete in this report. When this sensitivity data is available, acceptance criteria should be presented, and discussion of this and other models and their performance against the acceptance criteria should be included.*

    See general response # 3.

27. *There is no description of the procedure for calibration of the model. It appears that the model is run with input data from the boundaries and assumptions regarding other variables (aquifer – river interchange) with default values for most of the parameters. The procedure for modification of the default parameters should be explained, and the default and final parameters should be presented and compared.*

    We will include more text explaining the calibration process in the final report.

28. *Hydrodynamic calibration of the model is critical according to Tom Cole and Scott Wells. There is no indication whether a model can be hydrodynamically calibrated and balanced, and used as a tool for variations of other parameters that affect water quality without running the entire hydrodynamic portion of the model simultaneously. If this could be accomplished it would apparently reduce run-time significantly for assessing alternative inputs (meteorology, waste loads and temperature) and how they affect water quality.*

    CEQUALW2 is used primarily because there is a feedback between water quality and hydrodynamics. This is especially evident in Long Lake and less so in the river sections. There will be efforts to improve model run simulation time.

29. *The calibration of water quality constituents is a key element of instilling users with confidence in the Model's credibility as a tool in identifying causes for dissolved oxygen concentration falling below the water quality standards. It has been acknowledged that the reports and documentation provided to date (and currently available for comment) are not yet complete, and in some cases not yet started. It is appreciated that Ecology will allow for a thorough review of the calibration results, including summary of parameter adjustments to achieve optimum calibration. It is recommended that all parameter adjustments be carefully documented during calibration. Sensitivity of model output to the changes needs to be discussed.*

    These tasks will be done.

30. *It is our understanding that the Spokane River is one of the first applications of the CE-QUAL-W2 model to stretches of free-flowing river. Based on the available reports and users manual documentation, it is difficult to understand the relative importance of cascading action and wind as reaeration functions in the free-flowing sections, and even if wind contributes at all to reaeration in the model for river sections.*

    In the river sections, wind is not playing any role in reaeration – it is only a function of bed-shear induced turbulence.

31. *The model was only extended through October in the 2000 calibration. Extension through the rest of the year should be considered, especially since 2001 will be used for calibration as well.*

    We agree and will extend the model when the model is applied to 2001 conditions.

CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.1, User Manual, and Workshop

General responses to comments 32-39

We provided the workshop to representatives of the dischargers so they could become familiar with using the model and the specific Spokane model application. As noted in response to comment #6, the model is more complicated to apply and use than simpler models, but the complexity of the system and the dynamic simulation will provide a more accurate assessment of the impacts of pollutant loading. We believe that the benefits of the model outweigh the somewhat more difficult aspects of running and analyzing the model results. We also believe that with additional experience the model users will learn how to conduct model scenario runs and analyze results more efficiently.

The current model's run-time is of particular concern for calibration, but should not prove to be a liability when using the model as a management tool. A year simulation currently takes about 36 hours of CPU time or two days wall clock time. The time necessary to plot, analyze, and understand the model output is approximately the same, so the bottleneck in applying the model is equally attributable to analyzing model results. Currently, we do not see runtimes as a liability in applying the model.

32. *This is a very impressive model, and appears to be well suited to accurate simulation of conditions in the river. If other shortcomings can be overcome, it appears that this model will provide the most accurate tool for analyzing cause and effects on water quality in the Spokane River, Long Lake system.*

    No response needed.

33. *This model is very cumbersome to use due to the time consumption for each model run. Efforts to shorten run-time will hopefully be successful, and if successful will be very beneficial.*

    We will try to improve the model run times, but the run times are not unusual for a dynamic model.

34. *The model is currently incomplete for the intended use of evaluation of alternative scenarios that affect water quality in the Spokane River and Long Lake system. Calibration has not been completed for the 1991 and 2000 years adequately since statistical data on errors is not yet available.*

    Statistical data are available in a separate Excel spreadsheet on the web site. After final calibration these data will be merged into the report.

35. *There are elements to the model which were still being incorporated according to the developers at Portland State University. These elements include branch or segment association with different wind sheltering coefficients. These revisions to the model will prolong the calibration, error statistic determination and sensitivity analysis.*

    Yes.

36. *Sensitivity of the model output to the various parameters is not yet explained adequately. This aspect of model development has apparently not been completed, and based on available documentation may have not yet begun. Sensitivity analysis is of primary importance in terms of public comment and review because it will allow for input into the development of reasonable alternatives for water quality management and enhancement.*

    This analysis will be performed and included in the model calibration report.

37. *Selection of the model parameters needs additional explanation. Such items as kinetic constants, half-saturation coefficients, stoichiometric coefficients, and environmental limitations for biological growth need to be sourced.*

    These explanations are given in standard textbooks and hence it was not deemed necessary to include them in the model report. See the *CE-QUAL-W2 User's Manual* or *Surface Water Quality Modeling* by S. Chapra.

38. *Due to the long run times for this model, it is important to re-establish some of the functions of the model which were said to be not working at the February CE-QUAL-W2 training seminar. In particular: The RESTART output file function, if working properly, may allow shorter run times for some river segments. Other potentially time-saving functions which need to be brought up-to-date with the latest version of CE-QUAL-W2 include CST FLUX, and FLUXES.*

    The RESTART function will be activated in the Version 3.1 code.

39. *Other model modifications to reduce run time, and to eliminate repetitive calibration of some parameters (flow) each model run would also be beneficial. If a single flow calibration could be used for variations in other parameters concerning water quality without the overhead of recalibration of flow each run, it may be possible to shorten run-time. This would make multiple runs to accomplish sensitivity analysis and evaluation of variables or alternatives less time consuming, and in turn allow more runs.*

    We will try to reduce model run times.

    BC:cn